LUMBINI BUDDHIST UNIVERSITY

SYLLABUS

ON

MASTERS OF SCIENCE

IN

BUDDHIST STRUCTURAL ENGINEERING

[MScBSE]

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THE CONTEXT

Lumbini Buddhist University (LBU) was established in Lumbini through LBU Ordinance in 2004 in response to the 1st World Buddhist Summit in Lumbini in 1998, and later endorsed by its own Act in 2006.

As outlined in its 2030 Vision Seven Initiatives, LBU expanded its programs by creating the School of Development Studies & Applied Sciences (SDSAS) in accordance to the Article 9D of its Act and by the decision of its 11th Senate Meeting held on August 14, 2019 in Lumbini.

In accordance with the decision number 6 of the 11th Senate held in Kathmandu on August 14, 2019, and as per the instruction of Executive Council following on clustering of academic programs, decision was made by a meeting of Deans chaired by Vice Chancellor on October 3, 2019 to include the ongoing two programs such as M.Sc. in Construction Engineering & Management and M.Sc. in Disaster Risk Engineering and Management within the domain of SDSAS.

The three master level engineering management programs that were approved by the LBU's 7th Senate held in Kathmandu on June 16, 2016 are as follows:

i. M.Sc. in Construction Engineering & Management (CEM)
ii. M.Sc. in Disasters Risk Engineering & Management (DREM) and
iii. M.Sc. in Rural Infrastructure Engineering*

In the meeting held on May 12, 2022, the subject committee of LBU along with the experts as illustrated in Annex 1 suggested to change the title of the MSc. in Rural Infrastructure Engineering to MSc. in Buddhist Structural Engineering.

Upon receiving LBU's letter of affiliation dated December 13, 2015, the Lumbini International Academy of Science and Technology (LIAST) had started two programs and are currently running which are

i) M.Sc. in Construction Engineering & Management, and
ii) M.Sc. in Disasters Risk Engineering & Management.

After the Gorkha earthquake in April, 2015 and numerous aftershocks made the necessity of MSc. in Buddhist Structural Engineering course to be taught in the Master level. With a purpose of mainstreaming the technical engineering knowledge, LBU decided to run a program of MSc. in Buddhist Structural Engineering. The course content and syllabus were developed and reviewed multiple times by the experts and subject committee of LBU. This program will help to develop and transfer various types of civil engineering technologies and the analysis capacity of the students. In addition, the established a state-of-the-art lab for the study and research of the above-mentioned subjects will be the aid to the students.

THE PROGRAM

Program Course Title

M.Sc. in Buddhist Structural Engineering [MScBSE]

The Objectives of the Program

This Master of Science in Buddhist Structural Engineering [MScBSE] with theory, practical and research components aims:

- Retain a strong grasp of engineering fundamentals and critical thinking skills that enable students to consistently and successfully apply structural engineering principles within their chosen career path.
- Graduates from this course will be familiar with the analysis and design of different types of structural forms and materials.
- Conduct independent research in topics related to structural engineering.

To achieve the aforesaid objectives, M.Sc. Buddhist Structural Engineering Program of LBU, offers Main Core Courses and diversified Elective Courses with many case studies, project works and their research works in this particular field.

It is envisioned that the graduates of this program will be capable to design and analyze the complex infrastructure projects and carry research project in the area of Buddhist Structural Engineering along with the Buddhist Structures (e.g., stupas, shrines, monasteries, etc.)

Procedure for admission

- **Application form**

  The application form will be distributed for the entrance exam. Candidates who are interested in the enrollment in MScBSE will fill up this form.

- **Course for entrance exam (Syllabus for entrance exam)**

  The designed course for appearing in the entrance exam will be provided to the students who have already filled up the application forms.

- **Entrance exam (i.e. as per the syllabus prepared by the college)**

  The candidate shall appear in the entrance exam within the time allocated for the entrance exam.

Entry Requirements for Admission

The minimum requirement to apply for admission into the program is that candidate must hold a four years Bachelor of Engineering (BE) in Civil Engineering from a recognized university. The candidate shall appear and pass the admission test.

Total Credits

The MScBSE program offers 60 credits in accordance with the qualification framework for master-level programs as recommended by the University Grants Commission (UGC) (HEQFDT, 2016:8), and also to be incompatible with the norms followed at the IoE-TU.

Pedagogy

LBU follows the 2016 Higher Education Qualification Framework as approved by the University Grants Commission. It includes definitions of credit, lecture hours, practical, minimum qualification and other relevant criteria.

For the purposes of this program also, pedagogical approaches will be based on the UGC's framework as elaborated in the **Table 1**.

Table 1. Definitions of Credit Hour

Types of Study (One credit hour equivalent)	Engaged Learning Hours (minimum)	Independent Learning Hours (minimum)	Total Hours
1. Lecture hour	15	30	45
2. Hours of lab studies	45	30	75
3. Hours of field studies	45	30	75
4. Hours of clinical studies	45	30	75
5. Hours of industrial training	90	30	120
ours of self-study or online study or distance study	-	45	45

Source: HEQFDT, 2016

SYLLABUS AND CURRICULUM

The Master of Science in Buddhist Structural Engineering [MScBSE] degree program includes 7 regular courses (each of 100 marks), four electives (each of 100 marks) and a thesis of 400 marks. Out of four electives, students will select 2 subjects in the second semester and two subjects in the third semester.

Each course offered by the institute is identified by four letters, MBSE, followed by three numerical digits. The first digit denotes the year in which the course is normally taken. The first digit of 5 and 6 indicates the first and second year respectively of Master's level course. The second digit 0 and 5 are used for course offered in the first and second semester respectively. The third digit is used to identify the particular course. For the purposes of this program, an alpha-numerical Course Code has been adopted. It includes three alphabets representing the course title and three digits reflecting on the respective semester.

The course offered are listed as follows:

M.SC. in Buddhist Structural Engineering

A. CORE COURSES

MBSE 500: Advanced Structural analysis & mechanics of materials	4 Credits
MBSE 501: Solid Mechanics	4 Credits
MBSE 502: Structural Dynamics	4 Credits
MBSE 503: Advanced Design of Concrete Structures	4 Credits
MBSE 550: Seismic Resistant Design of structure	4 Credits
MBSE 552: Design of Foundation	4 Credits
	Total credits 24

B. ELECTIVE COURSES

[Two courses in 2nd Semester and Two courses in 3rd Semester]

MBSE 504: Disaster risk management	4 Credits
MBSE 505: Design of Trail Bridge	4 Credits
MBSE 506: Structural health monitoring	4 Credits
MBSE 600: Theory of Plate and shell structure	4 Credits
MBSE 555: Design of Industrial Structures	4 Credits
MBSE 556: Nonlinear structure analysis	4 Credits
MBSE 551: Design of Motor Bridges	4 Credits
MBSE 553: Application of Finite Element Method (FEM)	4 Credits
MBSE 602: Structural Engineering Laboratory	4 Credits
MBSE 603: Design of Hydraulic Retaining Structures	4 Credits
MBSE 604: Pre-stressed concrete	4 Credits
MBSE 605: Rock Mechanics and Tunneling	4 Credits
MBSE 606: Buddhist Infrastructure Engineering	4 Credits
	Total credits 16

C. PROJECT WORK **4 Credits**

MBSE 559: Project work in Structural Engineering

Project work shall be arranged related to the Buddhist structures as far as possible.

D. RESEARCH WORK (THESIS)

MBSE 650: Research in Structural Engineering **16 Credits**

Research shall be arranged related to the Buddhist sites and Buddhist structures as far as possible.

Grand Total Credits 60

SYLLABUS AND CURRICULUM

The Master of Science in Buddhist Structural Engineering degree program includes 7 regular courses (each of 100 marks) and a thesis of 400 marks. Thirteen courses will be electives (Two electives in the second semester and two electives in the third semester will be offered. Students will select 1 subject from each elective from the second semester and third semester).

ırse Structure of MSc in Buddhist Structural Engineering

ırse Code	Title of Course	Total Credits		Total Credits	Full Marks
		Theoretical	Tutorial		
r I/I	**Semester I**				
SE 500	Advanced structural analysis and mechanics of materials	4	0	4	100
SE 501	Solid mechanics	4	0	4	100
SE 502	Structural Dynamics	4	0	4	100
SE 503	Advanced Design of Concrete Structures	3	1	4	100
	Total	**15**	**1**	**16**	**400**
r I/II	**Semester II**				
SE 550	Seismic Resistant Design of structures	3	1	4	100
SE 552	Design of foundation	4	0	4	100
tive I (Choose one)					
SE 504	Disaster risk management	4	0	4	100
SE 505	Design of Trail bridge	4	0	4	100

urse Structure of MSc in Buddhist Structural Engineering					
urse Code	Title of Course	Total Credits		Total Credits	Full Marks
		Theoretical	Tutorial		
3SE 506	Structural health monitoring	4	0	4	100
3SE 602	Structural Engineering Laboratory	4	0	4	100
ctive II (Choose one)					
3SE 600	Theory of Plate and shell structures	4	0	4	100
3SE 555	Design of Industrial Structures	4	0	4	100
3SE 556	Nonlinear structure analysis	4	0	4	100
SE 551	Design of Motor Bridges	4	0	4	100
SE 553	Application of Finite Element Method (FEM)	4	0	4	100
	Total	**15**	**1**	**16**	**400**
r II/I	**Semester III**				
SE 559	Project Work	1	3	4	100
tive I (Choose one)					
SE 603	Design of Hydraulic Retaining Structures	4	0	4	100
SE 604	Pre-stressed concrete	4	0	4	100
tive II (Choose one)					
SE 605	Rock Mechanics and Tunneling	4	0	4	100
SE 606	Buddhist Infrastructure Engineering	4	0	4	100
	Total	**9**	**3**	**12**	**300**
r II/II	**Semester IV**				
SE 650	Thesis on a relevant topic as prescribed by the department (in	16		16	400

rse Structure of MSc in Buddhist Structural Engineering					
rse Code	Title of Course	Total Credits		Total Credits	Full Marks
		Theoretical	Tutorial		
	close coordination with the student) Research shall be arranged related to the Buddhist sites and Buddhist structures as far as possible				
	Total	**16**		**16**	**400**

Year I, Semester I

Core Subjects

MBSE 500: Advanced structural analysis and mechanics of materials

Year I, Semester I	
Course Title: Advanced structural analysis and mechanics of materials	Course Code: ***MBSE* 500**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To provide advanced and modified concept of matrix method required for structural analysis.
- To identify and observe the microscopic mechanisms responsible (as crystal structure) for the improved performance and properties of selected types of modern materials.

Course Content

Unit 1. Matrix Analysis of Frames (6 hrs.)

- Matrix Displacement Analysis of Planar Rigid-Jointed Frames
- Neglect of Axial Strain in the Analysis of Planar Rigid-Jointed Frames,
- Inclined Supports,
- 2D-frames with different end conditions,
- Bending moment diagrams

Unit 2. Boundary conditions, boundary value problems (3 hrs.)

- Approximate solution of boundary value problems,
- Modified Galerkin method for one-dimensional bar and beam
- Boundary value by Ritz approach.

Unit 3. Stiffness Matrix for Plates and Shells (6 hrs.)

- Plate analysis
- Element Stiffness Matrix & its application
- Conventional and numerical methods and stiffness matrix
- Plate problems

- Monarchies shell structure.

Unit 4.Stiffness Matrix Analysis of Three-Dimensional Structures (6 hrs.)

- Co-ordinate system and Transformations,
- Application to Space Trusses & Space Frames.
- Tetrahedral and Hexahedral elements, a
- Analysis of 3D frames

Unit 5. Introduction and structure of materials, properties of materials (6 hrs.)

- Introduction and structure of materials,
- Properties of materials and structure of atoms –
- Quantum states-atomic bonding in solids.
- Binding energy-interatomic spacing - variation in bonding characteristics –
- Single crystals, BCC, FCC.
- Type's polycrystalline – • Non crystalline solids –
- Imperfection in solids "Vacancies Interstitials – • Geometry of dislocation
- Schmidt's law
- Surface imperfection –
- Importance of defects - microscopic techniques –
- Grain size distribution.

Unit 6. Solid solutions and alloys - phase diagrams (6 hrs.)

- Solid solutions and alloys
- Phase diagrams
- Gibbs phase rule
- Single component systems "Eutectic phase diagram lever rule
- Study of properties of phase diagrams
- Phase transformation
- Nucleation kinetics and growth.

Unit: 7. Mechanical property (6 hrs.)

- Mechanical properties - Stress, Strain, Elastic properties; Deformation Elasticity hardness, fatigue
- Optical properties
- Light interaction with solids
- Atomic, electronic interaction, - refraction, reflection, Absorption, Transmission, Insulators, luminescence.

Unit 8. Magnetic properties (3 hrs.)

- Magnetic properties, paramagnetic, ferromagnetism - domain theory - magnetic hysteresis, Weiss molecular field theory,
- Heisenberg's theory - magnetic anisotropy - domain walls
- Exchange energy, anti- ferromagnetic

Unit 9. Structure and materials (3hrs.)

- Structure and materials used in the modern day Buddhist monasteries.

Reference Books

1. Callister, W.D. (2007). *Materials Science and Engineering: An Introduction*, John Wiley & Sons.
2. Pillai, K.V. & Parthasarathi, M. (2013). *Functional Materials: A Chemistâ Perspective* , Orient Blackswan
3. Kittel, C. (2005). *Introduction to Solid State Physics*, Wiley Eastern Ltd.
4. Raghavan, V. (2006). *Materials Science and Engineering: A First Course*, Prentice Hall
5. Dekker, A.J. (2000). *Solid State Physicsâ*, Macmillan & Co.
6. Shur, M. (1995). *Physics of Semiconductor Devices*, Prentice Hall of India.

MBSE 501: Solid Mechanics

Year I, Semester I	
Course Title : Solid Mechanics	Course Code: ***MBSE* 501**
Nature of the Course : Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objective

- To make the students capable of analyzing properties material and structure leading to theoretical approach of advance structural behavior of material and resistance of structure.

Unit 1. Analysis of Stresses and Strains (3 Hrs.)

- Concept of stress at a point,
- Stress tensor,
- Stress on inclined plane
- Stress components on a rectangular parallelepiped in Cartesian coordinate system.
- Transformation of stresses.
- The state of strain at a point, stress and strain displacement relations,
- Strain compatibility condition and stress compatibility conditions
- Relations between Elastic Constants • Boundary value problems in Elasticity.

Unit 2. Stress-Strain Relationship (3 Hrs.)

- Generalized Hook's law for Isotropic, Orthotropic, plane stress, plane strain and axisymmetric problems
- Problems in 2D and 3D Cartesian coordinate system, Airy's stress function, bending of
- Beams, bending stress.

Unit: 3. Polar Coordinate System (6 Hrs.)

- Relationship between Cartesian and Polar coordinate system
- Equilibrium equations, Strain displacement relations, Stress-strain relationship, Strain displacement relationship for plane stress and plane strain conditions.

Unit 4.Stress concentration problems (6 Hrs.)

- Stress concentration problems such as stress concentration due to circular hole in
- stressed plate (Kirsch's Problem)
- Stresses under concentrated load such as concentrated load acting on the vertex of a wedge

(Michell's Problem) and Concentrated load acting on the free surface of a plate (Flamant's Problem)

- Axisymmetric Problems such as stresses in thick cylinders Subjected to internal and
- External uniformly distributed pressures (Lame's Problem).

Unit 5.Beams Curved in Plan and Elevation (9 Hrs.)

- Analysis of Beams Curved in Plan such as cantilever circular arc, Semicircular beams fixed at two ends and subjected to central concentrated load, simply supported semicircular beam
- UDL supported on three equally spaced columns
- Analysis of circular ring beam.

Unit 6. Torsion(6 Hrs.)

- Assumptions and Torsion equation for general prismatic solid bars
- Warping of Non-circular Sections and St. Venant's theory, Prandtle's stress function
- approach
- Torsion of Circular, Elliptical and Triangular cross-section • Torsion of thin-walled structures by membrane Analogy
- Torsion of rolled sections and shear flow.

Unit 7.Beams on Elastic Foundation (6 Hrs.)

- Differential equation
- Infinite beams with concentrated load, concentrated moment, and finite uniformly distributed load.
- Semi-Infinite beams with free & hinged ends subjected to finite uniformly distributed load, hinged end.
- Finite beams with free end and hinged end.

Unit 8. Axisymmetric structures (6 Hrs.)

- Buddhist Monastery analysis
- Static Equilibrium equations
- Strain displacement relations; Stress-strain relationship; compatibility equations
- Plane stress and Plane strain conditions in axisymmetric problem
- Cylinders and shell structure subjected to internal and external pressure
- Plate membrane and bending theory,

Reference Books

1. Crandall, S., Dahl, N. and Lardner, T. (2007). *Mechanics of Solids*, McGraw Hill Publications
2. Bhavikatti, S.S, (2010). *Structural Analysis-II*,Vikas Publishing House, Pvt Ltd.
3. Volterra, E. and Gaines, J.H. (1971). *Advanced Strength of Materials*, Prentice Hall
4. Nautiyal, B.D. (2001). *Introduction to Structural Analysis*,New Age International Publishers
5. Kazimi, S.M.A. (2001). *Solid Mechanics*, Tata McGraw-Hill Publications
6. Shames, I. (1964). *Mechanics of deformable solids*, Prentice Hall
7. Sechler, E. E. (1952). *Elasticity in Engineering*, McGraw, Hill Publications
8. Singh, S, (1662). *Theory of Elasticity*, Khanna Publishers
9. Srinath, L.S. (2008). *Advanced Mechanics of Solids*, Tata McGraw-Hill Publications
10. Bairagi, N.K. (2008). *Advanced Solid Mechanics*, Khanna Publishers, New Delhi.
11. Timoshenko, S.P. and Goodier, J.N. (1951). *Theory of Elasticity*, McGraw-Hill Publications
12. Wang, C.T. (1953). *Applied Elasticity*, Dover Publications

MBSE 502: Structural Dynamics

Year I, Semester I	
Course Title : Structural Dynamics	Course Code: ***MBSE* 502**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To understand the behavior of structure especially building to various dynamic loads: such as earthquake, wind, machine vibration and ambient vibration.

Unit 1. Introduction to dynamic system (3 Hrs.)

- Nature of exciting forces
- degrees of freedom and mathematical modeling of dynamic systems
- Single degree of freedom system (SDOF)
- un-damped and damped free vibrations
- Viscous and Coulomb damping
- structural dynamics as applied to the Buddhist architecture

Unit 2. SDOF system in general (6 Hrs.)

- SDOF system: Un-damped and damped vibrations.
- Forced vibrations due to harmonic excitations.
- Fourier analysis of periodic forces and periodic excitations.
- Response to unit impulse
- Arbitrary loading by Duhamel's integral.

Unit: 3. SDOF discrete system (6 Hrs.)

- SDOF system: Step and Ramp forces
- Pulse loadings
- Response to ground motion
- Transmissibility.

Unit 4. Nonlinear system (6 Hrs.)

- Non-linear analysis by step-by-step method with linear acceleration

Unit 5. MDOF analysis (6 Hrs.)

- Multiple degrees of freedom (MDOF) system
- Free vibrations of a shear building,
- Fundamental frequencies and mode shapes

Unit 6. Mode shapes (6 Hrs.)

- Orthogonality of mode shapes, Power and Stodola's methods
- Concept of Tuned Mass Damper

Unit 7. MDOF Response (6 Hrs.)

- MDOF System: Forced Vibrations of shear building,
- Transformation of coordinates and mode Superposition method,
- Response to ground motion.
- Non-linear analysis by Wilson-Theta method.

Unit 8. Continuous system (6 Hrs.)

- Partial differential equation of motion (for string, bar, beam)
- Transverse vibration of a beam and string
- Axial vibration of a bar
- Free vibration analysis of a cantilever beam by Rayleigh Ritz and Finite Element Method. All related to Buddhist structure.

Reference Books

1. Poultre, P. (2013). *Dynamics of structures*, Wiley, India
2. Paz, M. (2004). *Structural Dynamics Theory and Computation*, CBS Publications
4. Clough, R.W., Penzin, J. (1993). *Dynamics of Structures*, McGraw Hill Publications
5. Roy, R.C. (1981). *Structural Dynamics an Introduction to Computer Methods*, John Wiley & Sons Publications
6. Mukhopadhyay, M. (2000). *Structural Dynamics Vibrations and Systems*, Ane Books India Publishers

MBSE 503: Advanced Design of Concrete Structures

Year I, Semester I	
Course Title : Advanced Design of Concrete Structures	Course Code: ***MBSE* 503**
Nature of the Course: Theory + Practical	Per week Hours: (3+1)
Credit: 4	Total Hours: 60

Course Objectives:

- To provide basic concepts for the design of various reinforced concrete elements with codal provisions.
- To gain knowledge of advance design of reinforced concrete structure.

Unit 1. Introduction (6 hrs.)

- Review of limit state Design for shear, flexure, torsion and combined stresses of beams, slabs & slender columns according to IS 456-2000. Safety and serviceability,
- Calculation of deflection & crack width according to NBC105: 2020, IS 456-2000.
- Factors affecting Crack width in beams,
- Mechanism of Flexural cracking,
- Calculation of crack widths,
- Simple Empirical method,
- Estimation of Crack width in beams by IS 456 of BS 8110,
- Shrinkage and Thermal Cracking;
- Use of concrete structures in Buddhist architecture.

Unit 2. Deflection criteria Design of special RC elements (9 hrs.)

- Introduction -Short-term Deflection of beams and Slabs by IS 456
- Calculation of deflection by other codes (BS 8110 , Eurocode , ACI)
- Deflection of Cantilever beam and slab
- Design of slender columns,
- Grid floors, curved, inclined beams, Deep beams,
- Plain and reinforced concrete walls,
- Corbels & Edge (Spandrel) Beams,
- Reservoir,
- Shear wall.

Unit 3. Design of Slabs (9 hrs.) •

- Introduction
- Checking for One-way (wide beam) shear
- Two-way (Punching) shear
- Permissible punching shear –
- Shear due to Unbalanced Moment (Torsional moments)
- Calculation of j values
- Strengthening of column areas for moment transfer by torsion which produces shear, Shear Reinforcement Design,
- Effect of openings in Flat slabs
- Recent Revisions in IS code, Shear in two-way slabs with beams
- Design of circular a flat slab.
- Yield line analysis of slabs,

Unit 4. Design of Folded plates and dome (9 hrs.)

- Buddhist architectural folded plates and Monasteries,
- General features and types,
- Structural behavior,
- Analysis and design of sectorial plates,
- Design using program and CAD.
- Connectivity analysis and design of folded plates.
- Fixed and hinged type connection.
- Edge zone features of folded plates.
- Monarchies folded plate or Gumba design

Unit 5. Design of Shear wall (9 hrs.) •

- Introduction
- Classification of shear walls,
- Classification according to behavior,
- Loads in shear walls,
- Design of Rectangular and flanged shear walls,
- Derivation of formula for moment of Resistance of Rectangular shear walls in basement and lift

Unit 6. Prestressed and post tension concrete structure Design (3 hrs.)

- Design of statically determinate and indeterminate prestressed and post tension concrete structure (bridge, electric poles, slab etc.).
- Use of structures in Buddhist architecture.

References:

1. Purushothaman, P. (1984). *Reinforced Concrete Structural Elements: Behavior, Analysis and Design*, TATA McGraw Hill
2. Dayaratnam, P. (2017). *Limit State Design of Reinforced Concrete Structures*, Oxford & IBH Publishers
3. Krishna Raju N. (2016). *Advanced Reinforced Concreted Design*, CBS Publishers& Distributors
4. Varghese, P.C. (2005). *Advanced Reinforced Concrete Design*, Prentice Hall of India
5. Bhavikatti, S. S. (2008). *Advanced RCC design Volume II*, New Age International
6. Ramamurthum, S. (2015). *Reinforced Concrete Design of Structures*, Dhanpat Rai Publishing Co Pvt. Ltd.

Core Subjects

MBSE 550: Seismic Resistant Design of structures

Year I, Semester II	
Course Title : Seismic Resistant Design of structures	Course Code: ***MBSE* 550**
Nature of the Course : Theory + Practical	Per week Hours: (3+1)
Credit: 4	Total Hours: 60

Course Objectives:

- The main objective of this course is to understand the nature of earthquake, behavior of structures under the ground motion, and learns the analysis and design of structures subjected to seismic load.

Unit 1. Introduction of Seismic Resistant Design (3 Hrs.)

- Characteristics of earthquake
- Seismic response of structures
- Concept of earthquake resistant design
- Codal provision for design of buildings in vulnerable seismic zones
- Introduction to design of liquid storage tanks, liquefaction, non-engineered construction
- Effects of Seismicity; Theories and application of seismic resistant
- Design; Basic requirements for Seismic Resistant Structures.
- Base shear criteria in seismic analysis; seismic resistance of stupas and Buddhist monasteries.

Unit 2. Seismology and Causes of Earthquake (6 Hrs.)

- Earthquakes and Seismic hazard
- Causes of Earthquakes
- Mechanism of Earthquakes
- Measures of Earthquakes
- Attenuation Laws;
- Response Spectrums of Earthquakes
- Seismic Zoning; Seismic Hazard Analysis Earthquakes, Epicenter, Hypocenter and earthquake waves
- Measurement of ground motion, Seismic regions, Intensity and Isoseismics of an earthquake, Magnitude and energy of an earthquake

- Consequences of earthquakes
- Earthquake Response of Linear Systems: Earthquake excitation, Equation of motion.

Unit 3. Probability criteria in Seismic Resistant structure (6 Hrs.)

- Random and scattered Variables
- Distribution Functions; Multi-dimensional and MDOFRandom Variables •
- Conditional Probability
- Statistical Independence; Central Limit Theorem; Liapanov's and Linderberg Feller's Theorems
- Probability and seismic consideration to seismic design of structure
- Time history, Response spectra.

Unit 4. Response Spectra of Structures (6 Hrs.)

- Review of Single Degree of Freedom System to Support lateral Movement
- Mode Shapes and Frequencies of Multi Degrees of Freedom System
- Normal Mode Theory and analysis
- Mode Participation Factors
- Pseudo Static Force in Each Mode of Vibration due to earthquake. Response quantities,
- Pseudo-velocity, and Pseudo-acceleration
- Peak structural response from the response spectrum,
- Elastic design spectrum
- Comparison of design and response spectra

Unit 5. Structure resisting seismic forces. (6 Hrs.)

- Different Structural Systems for Seismic loads; Floor Diaphragms and constraints; central, cantilever rigidity consideration.
- Seismic Load distribution with Rigid Floor Diaphragms
- Moment Resisting Frames; Seismic Load Distribution in Framed Buildings
- Shear Walls; Shear Wall with Openings • Frame – Shear and masonry wall System.

Unit 6. Response Spectra (3 Hrs.)

- Theory and development, tripartite response spectra
- Response Spectrum Analysis for MDOF System
- Time History Analysis of MDOF System for Single and Multi-point excitations, response spectra and application for soil treatment

Unit 7. Seismic-Hydro- Dynamic Effects. (3 Hrs.)

- Seismic resistant design of Dam, submerged building.
- Vibration and seismic design consideration for Liquids intze Tanks, underground water tanks
- Vibrations of Submerged Structures like Piers and abutments
- Floating bridges. Hydrodynamic pressures in tanks.

Unit 8. Seismic Resistant Design and considerations (6 Hrs.)

- Seismic Design concepts
- Principles of frame design,
- R.C. Ductile frames, shear walls, Masonry structures, composite structures, drift and lateral stability criteria,
- Seismic Resistant Design of tall and vulnerable buildings.
- Choice of earthquake resisting systems for low rise, medium and high rise buildings.
- Behavior of RCC members under cyclic loading.
- NBC, IS and other international code Provision for Various Structures
- Seismic Design of Multistory buildings: seismic coefficient method and Response spectrum method, Base shear, Fundamental period of buildings, Distribution of forces along the height Seismic design of elevated towers: Introduction,
- Behavior under seismic loads, Design features
- Water tower as a rigid jointed space frame
- Seismic design of Stack like structures: Introduction, Fundamental period of vibration, Dynamic bending moment, Shear diagram Monarchies, Stupa design with
- consideration of seismic forces

Unit 9. Seismic resistant design with consideration of ductility (3 Hrs.)

- Ductility of various structural materials
- Plastic Design and plasticity of Structures for Seismic Resistant
- Design Based on Energy Criterion • Ductility Factor Method
- Codal Provisions.

Unit 10. Vibration control techniques (3 Hrs.)

- Active and Passive Control,
- Various Technique of active and Passive Control,
- Base Isolation
- Concept, Dampers for seismic response mitigation,
- Retrofitting Technique for buildings, bridges and other structure.

References:

1. Bruce A. Bolt and W. H. (2005). *Freeman, Earthquakes* (5th edition), New York, 2003 ISBN 0-7167-5618-8. J Seismol 9, 127 https://doi.org/10.1007/s10950-005-2110-x
2. Naeim, F. (2001). *The Seismic Design Handbook*, Kluwer Academic Publishers Group, The Netherlands
3. Paulay, T. and Priestley, M.J.N. (1992). *Seismic Design for R.C. and Masonry Building*, John Wiley and Sons IS 1893,IS 13920,IS 4326
4. Kelly, M. (2018). *Seismic isolation*: From theory to practice: An introduction to seismic isolation:
5. Newmark, N. M., and Rosenblueth, E., (1971). *Fundamentals of Earthquake Engineering*, Prentice-Hall, Inc .Englewood Cliffs, N. J.
6. KRAMER, S.L. (1996*). Geotechnical Earthquake Engineering,* Prentice Hall, Upper Saddle River, NJ
7. Dowrick, D. (2009). *Earthquake Resistant Design and Risk Reduction*, John Wiley & Sons, Ltd.

MBSE 552: Design of Foundation

Year I, Semester II	
Course Title: Design of Foundation	Course Code: ***MBSE* 552**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- The course gives a basic understanding of the nature of soil, analysis of structures subjected to earthquakes and design of structures to resist in various type of soil strata below ground level for proper foundation type selection.

Unit 1: Soil Structure Interaction (12 Hrs.)

- Foundation objectives and their importance • Classification of foundations
- Soil classification.
- Geotechnical design parameters, bearing capacity, settlements and factors affecting settlement.
- Loads for design, depth of foundation and depth of soil exploration.
- Parameters For design of foundation on various types of soil, soil structure interaction.
- Foundations of monasteries in the high mountains, Kathmandu valley and Lumbini.

Unit 2: Design of Raft Foundations (9 Hrs.)

- Types of rafts foundation
- Design of flat slab raft foundation.
- Design of beam and slab raft foundation.

Unit: 3 Pile Foundation –I (15 Hrs.)

- Function and Classification of piles Concrete piles, Precast and cast-in-situ piles. •
- Static point and skin resistance capacity of a Pile
- Pile settlements.
- Laterally loaded Piles.
- Various pile group patterns, Efficiency of Pile in group, Negative skin friction.
- Shell Foundations: Types and applications,
- Soil structure interaction
- Membrane analysis for Hyper and Conical RC shells with and without edge beams, detailing of critical sections.
- Inclined pile analysis

Unit 4: Pile Foundation-II **(9 Hrs.)**

- IS code recommendation for structural design for various piles
- Design of RC cast-in-situ and precast pile by IS code method.
- Pile group analysis by rigid and flexible methods Design Of pile cap.

References Books

1. Kurain, N.P. (1982). *Modern Foundations: Introduction to Advance Techniques*, Tata McGraw Hill
2. Kurain, N. P, (2005). *Design of Foundation Systems: Principles and Practice*, Narosa Publishing house, New Delhi
3. Shah, Dr. H. J. (2008). *Reinforced Concrete*, Vol II, Charotar Publishing House.
4. Winterkorn, H.F. and Fang, H.Y. Ed. (1975). *Foundation Engineering Hand Book*, Van-Nostrand Reynold
5. Bowles, J.E. (1996). *Foundation Analysis and Design* (4th Ed.), McGraw Hill, NY
6. Poulose, H.G. and Davis, E.H. (1980). *Pile foundation Analysis and Design*, JohnWiley Sons, NY
7. Leonards, G. Ed. (1962). *Foundation Engineering*, Mc.Graw-Hill, NY
8. Prakash, S. (1981). *Soil Dynamics*, McGraw Hill
9. Sreenivasalu & Varadarajan, (2007). *Handbook of Machine Foundations*, Tata McGraw Hill
10. O'Neil, M.W. and Reese, L.C. (1999). *Drilled Shafts: Construction Procedures and Design Methods*, FHWA Publication No. FHWA-IF-99-025, Federal Highway Administration, Washington, D.C., USA
11. Varghese, P.C. (2009). *Design of Reinforced Concrete Foundations*, PHI Learning Pvt. Ltd., New Delhi
12. IS 1904: 1986 Code of Practice for Design and Construction of Foundations in Soils: General Requirements (Third Revision)
13. IS 2911: Part 1: Sec 1 to 3: 1979 Code of practice for design and construction of pile foundations: Part 1 Concrete piles
14. IS 2911: Part 1: Sec 4: 1984 Code of practice for design and construction of pile foundations: Part 1 Concrete piles
15. IS 2911: Part 3: 1980 Code of practice for design and construction of pile foundations: Part 3 Under-reamed piles
16. IS 2950: Part 1: 1981 Code of Practice for design and construction of raft foundations: Part 1: Design
17. IS 2974: Part 1to 5: 1982 Code of practice for design and construction of machine

Foundations

General Reading Suggested: Codes:

1) Reese, L.C. and O'Neill, M.W. (1988). *Drilled Shafts: Construction and Design*, FHWA, Publication No.HI-88-042, USA.

2) FHWA-NHI-10-016, (2010). *Drilled Shaft: Construction Procedures and LRFD Design Methods*, U.S. Department of Transportation Federal Highway Administration, Washington, D.C., USA.
(http://www.fhwa.dot.gov/engineering/geotech/foundations/nhi10016/nhi10016.pdf)

Hand books:

1) Fang, H.Y., Van Nostrand Reinhold, Kulhawy, F.H. (1991). "*Foundation Engineering Handbook Drilled Shaft Foundations*, Chapter 14, 2nd Ed., New York, pp. 537-602.

Elective I

MBSE 504: Disaster Risk Management

Year I, Semester I	
Course Title : Disaster Risk Management	Course Code: ***MBSE* 504**
Nature of the Course : Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To develop and enhance the capacity of students for management and mitigation of disasters and link disaster risk management with contemporary development practices through advancement and imparting of multi-disciplinary knowledge.

Course Contents:

Unit 1. Introduction to Disaster Risk Management (12 hrs.)

- Natural Disasters: Earthquake, Floods, Drought, Coastal Hazards, Landslides, Rockslides and Forest Fires
- Earthquake Phenomenon
- Earthquake recording instruments
- Introduction to Theory of Vibrations: Single degree un-damped and damped systems, elastic response to simple load functions and earthquake response spectra

Unit 2. Performance and response of Buildings and Structures (9 hrs.)

- Main causes of damage
- Intensity of earthquake forces
- Lack of strength, ductility, detailing and integrity in buildings

Unit 3. Earthquake Effects (9 hrs.)

- On ground and soil liquefaction, buildings, structures, power plants, switch yards, equipment and other lifeline structures, release of poisonous gases and radiation, Lessons
- Learnt from the Past Earthquakes: Case studies of important structures
- Nepal earthquakes and major world earthquakes

Unit 5. Disaster Management (9 hrs.)

- Disaster management cycle
- Salient features of disaster rescue, risk management and casualty management.
- Post disaster management.

Unit 6. Disaster Management in Nepal (6 hrs.)

- Disaster risk reduction (DRR) policies, rules and guidelines.
- National disaster risk reduction and management authority (NDRMA) - structure, roles and responsibilities.
- Best DRR practices in the world.

  Disaster risk reduction adopted in the Buddhist architecture such as monasteries and stupas etc.

References:

1. Dr. Indu Prakash. (1974). *Disaster Management*, Rashtra Prahari Prakashan, Sahibabad,Gaziabad.
2. Mukherjee, P.K. (2013). *A Text Book of Geology,* World Press Private Ltd.
3. Krishna,J., Chandrasekharan, A.R. and Chandra, B (1994). *Elements of Earthquake Engg*, South Asian Publishers, New Delhi.
4. Stratta, J.L. (1987). *Manual of Seismic Design,* Pearson Education, Singapore.
5. Manickaselvam, V.K. (2005). *Introduction to Earthquake Analysis and Design,* Dhanpat Rai

MBSE506: Structural Health Monitoring

Year I, Semester I	
Course Title : Structural Health Monitoring	Course Code: ***MBSE* 506**
Nature of the Course : Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To enhance the knowledge of student to do assessment of the existing structures affected by external factors
- To enhance the performance of structures
- Feedback loop to improve future design based in experience.

Unit 1 Introduction (12 Hrs.)

- Overview of SHM, necessity of SHM
- Passive and Active SHM
- Introduction to Smart Materials, Sensors. SHM using Optical Fibers and other sensors.
  - Overview on the notable Applications of SHM – Aerospace and Civil Applications
- Underground Structures and Other Applications.
- Understanding Piezoelectric Material
- Understanding Magnetostrictive Material and their use in SHM
- Structural health of Buddhist architectures such as monasteries and stupas etc.

Unit 2 Vibration based Techniques for SHM (12 Hrs.)

- Basic concepts, diagnosis levels, local and global methods, damage diagnosis as an inverse problem, model-based damage assessment, data-based damage assessment, experimental and analytical example
- Introduction to Finite Element formulation
- Constitutive Relationship, Element Stiffness Matrix for High Precision Finite Element, Mass Matrix for High Precision Finite Element
- Developing Actuator and Sensor Influence Matrix, Estimating Sensor Voltage, Active Control of Damping
- Case study of Performance Estimation for Different Patches, SHM of CFRP sheet and Composite Laminate sheet.

- Experimental and analytical examples; Damage detection using modal parameters: Formulation; Fundamental and higher mode shapes and their derivatives.

Unit 3 SHM using Piezo and Magneto strictive Layers (12 Hrs.)

- Delamination, Sensing using Piezo Sensory Layer assessment, AI, IAA1994, Mechanical Voltage Response from Piezopatch, Electrical Impedance Method: basic theory
- A Case Study. Results and Discussions SHM using Magnetostrictive Sensory Layer
- Basics of Magnetization and Hysteresis
- Delamination Sensing using Magnetostrictive Sensory Layer.
- Constitutive relationship with composite relationship MS Layer in symmetric Laminate
- MS Layer away from the Mid-plane in Asymmetric Laminate
- Case Studies related to MS Layer based SHM. Electro–Mechanical Impedance (EMI) technique
- Mechanical Impedance approach and relevance to SHM. Low-cost adaptations and other practical aspects of EMI technique
- Non-Destructive Evaluation (NDE) Techniques.

Unit 4 SHM using LDV (9 Hrs.)

- Introduction of LDV
- Experimental Modal Analysis using LDV Velocity and Displacement Measurement using LDV
- Case Study for Symmetric Laminate, Case Study for Cross-ply.

References:

1. Gandhi, M.V. Thompson, B.S. (1992). *Smart Materials and Structures, Gandhi and Thompson*, Champman & Hall, 2-6 Boundry Row, London SEI 8HN, UK
2. Chang, F. K. (1997). *Structural Health Monitoring: Current Status and Perspectives*, Technomic Publishing Group, Pennsylvania, U.S.A.
3. Bhalla, S., Moharana, S., Talakokula, V. and Kaur, N. (2017). Piezoelectric Materials: *Applications in SHM, Energy Harvesting and Biomechanics,* Ane Books Pvt. Ltd. (Indian Edition)
4. Ewins, D. J. (2000). *Modal Testing: Theory, Practice and Applications*, 2nd edition, Research Studies Press Ltd., Baldock.

5. Inman, D. J., Farrar, C.R., Steffan, V. and Lopes, V. (2005). *Damage Prognosis – For Aerospace, Civil and Mechanical Systems*, John Wiley & Sons, Ltd., Chichester, UK Related Journal Papers on SHM

MBSE 505: Design of Trail Bridge

Year I, Semester I	
Course Title : Design of Trail Bridge	Course Code: MBSE 505
Nature of the Course : Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To introduce trail suspension bridge and make capable to plan, analyze, design and construct trail suspension bridge.

Unit 1. Introduction (3 Hrs.)

- Nepal Trail Bridge Status
- Trail Bridge Institutions
- Types of Trail Bridges
- Types of Trail Bridge Foundations
- Types of Trail Bridge Substructures
- Bridges with Buddhist architectural designs

Unit 2. Trail Bridge Planning (3 Hrs.)

- Need Assessment
- Planning Tools
- Master Plans
- Rolling Plans
- Bridge Maintenance Plans

Unit 3. Pre-Feasibility/Feasibility Study (6 Hrs.)

- Desk Study, Field Survey and Data Collection
- Bridge Site Selection, Technical & Legal Analysis
- Social & Environmental Analysis
- Financial & Economic Analysis
- Options Development

Unit 4. Project Appraisal (3 Hrs.)

- Overall Project Concept
- Technical & Legal Aspects
- Social & Environmental Aspects

- Economic & Financial Aspects

Unit 5. Detail Engineering Design (3 Hrs.)

- Detail Engineering Survey
- Hydrological Investigation
- Geo-technical Investigation Trail Bridge Loading
- Detailed Engineering Design

Unit 6. Bridge Parts Transportation (3 Hrs.)

- Transportation of Foundations Parts/Equipment/Material
- Transportation of Substructure/Superstructure
- Parts/Equipment/Material

Unit 7. Trail Bridge Construction (6 Hrs.)

- Construction Materials
- Construction Equipment
- Bridge Layout on Site
- Bridge Construction Technology

Unit 8. Bridge Maintenance (6 Hrs.)

- Bridge Inspection
- Typical Failure Modes
- Trail Bridge Maintenance
- Planned Maintenance

Unit 9. Investment and Funding (3 Hrs.)

- Project Investment, Project Funding

Unit 10. Erection, Installation and Orientation of trial bridge (3 Hrs.)

- Erection, Installation and Orientation of Trial Bridge

Unit 11. R & D Dissertation on Relevant Topic (6 Hrs.)

- R & D Dissertation on Relevant Topic. Bridges with Buddhist architectural designs.

References:

1. *Company for International Technical Cooperation and Development.* (1983). Survey, Design, and Construction of Trail Suspension Bridges for Remote Areas. St. Gallen, Switzerland: SKAT, Swiss Center for Appropriate Technology.
2. Kraehenbuehl, J., Panciotto, D., Basnet, C. B., Wagner, A., Grob, A., & Maag, H. P. (1983).

Survey, Design and Construction of Trail Suspension Bridges for Remote Areas. St. Gallen: SKAT, Swiss Center for Appropriate Technology.

3. SBD, DOR & IOE. (2003). *Trail Suspension Bridges* (Course Manual)
4. Trail Bridge Section, GoN. (2002). *Short-span Trail Bridge Standard*, Technical Handbook, SKAT, Swiss Centre for Development Cooperation in Technology and Management Vadianstrasse 42, 9000 St. Gallen, Switzerland

MBSE 602: Structural Engineering Laboratory

Year I, Semester II	
Course Title : Structural Engineering Laboratory	Course Code: ***MBSE* 602**
Nature of the Course : Practical (Lab)	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To provide the students, hands on experience in testing and quality control of concrete making materials to design concrete mixes for different ranges of strength and workability.
- To provides knowledge of the experimental tests to assure and compare database results of strength, stiffness and stability of structures under possible different actions in any type of loading, material and support conditions.

Unit 1. Concrete Laboratory (6 Hrs.)

- Concrete tests: properties
- Tests for fresh light weight and hardened
- Concrete in successive duration, destructive and non-destructive testing, slump test, shear and compressive test.

Unit 2. Reinforced Concrete Laborator (6 Hrs.)

- Testing of Reinforced Framed structures,
- Testing of curved beam and RC Slab of various shapes

Unit 3. Pre-cast post tension Concrete Laboratory (6 Hrs.)

- Testing of precast, post tensioned concrete beams and slabs,
- Triangular rectangular slab testing

Unit 4. Steel timber aluminum test Laboratory (9 Hrs.)

- Testing for reinforcing bars,
- Steel section
- Timber and Aluminum sections
- Model Tests on still base plates of Buddhist monasteries, stupas, etc.

Unit 5. Dynamic mass testing of structure **(9 Hrs.)**

- Dynamic test on SDOF, MDOF system
- Determination of Mode Shape Frequencies of simple beam and frames and comparing results with analytical approach

Unit 6. Stress-strain analysis Laboratory **(9 Hrs.)**

- Stress- strain gauge test.
- Two- and three-dimensional photo elasticity
- velocity-pulse test

Notes: The course shall be outlined with a target of about 7 experiments.
List of experiments

1. Fabrication, casting and testing of simply supported reinforced concrete beam for strength and deflection behavior.
2. Testing of simply supported steel beam for strength and deflection behavior.
3. Fabrication, casting and testing of reinforced concrete column subjected to concentric and eccentric loading.
4. Dynamic testing of cantilever steel beam
5. To determine the damping coefficients from free vibrations.
6. To evaluate the mode shapes.
7. Static cyclic testing of single bay two storied steel frames and evaluate
    a. Drift of the frame.
    b. Stiffness of the frame.
    c. Energy dissipation capacity of the frame.
8. Determination of in-situ strength and quality of concrete using
9. Rebound hammer and
10. Ultrasonic Pulse Velocity Tester.
11. Effect of admixtures in concrete for workability, strength and durability

Laboratory equipment requirements

Strong Floor, Loading Frame, Hydraulic Jack, Load Cell, Proving Ring, Demec Gauge, Electrical Strain Gauge with indicator, Rebound Hammer, Ultrasonic Pulse Velocity Tester, Dial Gauges, Clinometer, Vibration Exciter, Vibration Meter, FFT Analyzer

References:

1. Dally, J. W. and Riley, W. F. (1991). *Experimental Stress Analysis*, McGraw-Hill Inc. New York
2. Lang, K. and Herwig, A. (2014). *Confinement of reinforced concrete columns*, 16, 271292, CRC Press, Boca Raton
3. Czaderski, C. (2013). *Flexural and Shear Strengthening of Reinforced Concrete Structures The International Handbook of FRP Composites in Civil Engineering Part III Externally Bonded FRP Composite Systems for Rehabilitation*

Electives II

MBSE 600: Theory of Plate and Shell Structure

Year I, Semester II	
Course Title: Theory of Plate and Shell Structure	Course Code: ***MBSE* 600**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To make the students able to analyze plate shell structure both in bending and membrane analogy.

Unit 1. Introduction (6 Hrs.)

- Introduction
- Buddhist Monasteries and Pillar Thin and thick plates
- Small and large deflections
- Small deflection theory of thin plates
- Assumptions, Moment Curvature relations. Stress resultants.
- Governing differential equation in Cartesian co-ordinates • Various boundary conditions
- Pure Bending of Plates.

Unit 2. Analysis of Rectangular Plates (3 Hrs.)

- Analysis of Rectangular Plates
- Navier solution for plates with all edges simply supported
- Distributed loads, point loads and rectangular patch load

Unit 3. Levy's Method (6 Hrs.)

- Levy's Method: Distributed load and line load
- Plates under distributed edge moments
- Raleigh- Ritz approach for simple cases in rectangular plates.
- Introduction to shear deformation theories. Reissener - Mindlin Theory
- Moment curvature relationship for First order shear deformation theory

Unit 4. Circular Plates (6 Hrs.)

- Analysis of circular plates under axi-symmetric loading
- Moment Curvature relations
- Governing differential equation in polar co-ordinates.

- Simply supported and fixed edges.
- Distributed load, ring load, a plate with a central hole.
- Buddhist Monastery analysis and design

Unit 5. Introduction (6 Hrs.)

- Introduction:
- Classification of shells on geometry
- Thin shell theory
- Equations to shell surfaces, stress resultants, stress- displacement relations, compatibility and equilibrium equations.
- Shells of Revolution: Membrane theory, equilibrium equations, strain displacement relations, boundary conditions, cylindrical, conical and spherical shells.

Unit 6. Circular cylindrical shells (6 Hrs.)

- Membrane theory: Equilibrium equations, strain displacement
- Relations, boundary conditions.

Unit 7. Bending Theory (6 Hrs.)

- Equilibrium equation
- Strain displacement relations,
- Governing differential equation,
- Solution for a simply supported cylindrical shell,
- Various boundary conditions.
- Application to pipes and pressure vessels.

Unit 8. Beam theory of cylindrical shells (6 Hrs.)

- Beam theory of cylindrical shells
- Principles of Lundgren's beam theory
- Beam analysis, arch analysis, and application to cylindrical roof shells.
- Design of meditation hall.
- Use of beam theory in Buddhist Architecture.

Reference Books

1. Timoshenko, S. and Krieger, W. (1959). *Theory of Plates and Shells*, Mc Graw Hill.
2. Ugural, A.C. (1998). *Stresses in Plates and Shells*, Mc Graw Hill
3. Ramaswamy, G.S. (2005). *Design and Construction of Concrete Shell Roofs*, CBS Publications
4. Chandrashekhara, K. (1995). *Analysis of Concrete Shells*, New Age International Edition
5. Chandrashekhara, K. (2001). Analysis of Plates, New Age International Edition

MBSE 555: Design of Industrial Structures

Year I, Semester II	
Course Title: Design of Industrial Structures	Course Code: ***MBSE* 555**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- To design industrial structures (steel and RCC) compatible to recent codes of practice.
- Steel Structures

Unit 1. Introduction to steel structures (6 Hrs.)

- Structural design and history of Steel Structures
- Structural System and concepts
- Loading: Gravity, wind and earthquake loading, impact loading, temperature load, Erection load, Explosion and fire load
- Stress types in steel: Secondary stress, multi axial stress, Fatigue stress
- Expansion joints
- Indian Standard rolled steel sections
- ASD and LFRD design philosophies
- Review of rivets, bolts, pins, welds
- Application of industrial structures in Buddhist architectures

Unit 2. Steel structural connections (6 Hrs.)

- Types of connections
- Shear connections,
- Stiffened and unstiffened beam connection
- Triangular bracket plates
- Beam column connections
- Beam to beam connection
- Rigid frame knees
- Column base plate connection
- Beam and column splices

Unit 3. Gantry Girder (3 Hrs.)

- Longitudinal and Lateral forces on crane girder
- Design examples

Unit 4. Transmission towers (3 Hrs)

- Transmission tower analysis and design
- Design of Transmission tower using CAD
- RCC structures

Unit 5. Bunkers and silos (3 Hrs)

- Introduction
- Design of square, rectangular and circular bunkers
- Design of silos
- Design of bunker and silos using CAD

Unit 6. Chimneys (6 Hrs.)

- Parts of chimneys
- Design philosophy
- Stresses in RC shafts due to various loads
- Stresses in horizontal reinforcing bars due to shear force
- Stresses induced by temperature forces
- Design of RC chimneys using charts and using CAD

Unit 7. Elevated water tanks (3 Hrs)

- Design example of overhead tanks and type of tank manually and using CAD

Unit 8. Shells (6 Hrs)

- Classification of shells element
- Analysis of hyperbolic and paraboloid shells,
- Analysis of membrane forces in shell
- Analysis for wind and earthquake loads in shells
- Design Examples using CAD

Unit 9. Folded Plates (3 Hrs.)

- Analysis and design of folded plates
- Structural behavior
- Stresses in Hipped plates
- Design Examples of folded plates using CAD

Unit 10. Grid or coffered floors (6 Hrs.)

- Approximate analysis and design of grid floors
- Design of ribbed slabs
- Design Examples of grid and ribbed slabs using CAD
- Application of this in Buddhist Structure.

References:

1. Syal, I. C. & Singh, G. (2020). *Design of steel Structures,* Standard Publishes
2. Chandra, Dr. R. (2016). *Design of steel Structures*, Standard Book House since 1960
3. Ramaswami, G. S. (2005). *Design and construction of concrete shells*, CBS Publishers And Distributors
4. The steel construction institute, (2016). *Steel designer's manual*; Wiley-Blackwell; 7th edition.

MBSE 556: Nonlinear Structural Analysis

Year I, Semester II	
Course Title: Nonlinear Structural Analysis	Course Code: ***MBSE* 556**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- This course presents systematic analysis procedures for geometric and material nonlinear structures. It introduces and encourages on the use of nonlinear analysis software. It explores the significance of common nonlinear phenomena, particularly in relation to the structural response under extreme events. Familiarize and explore the concept of nonlinear behavior and analysis of elements and simple structures.

Unit 1 Introduction to nonlinear structural analysis (6 Hrs.)

- Introduction to nonlinear structural analysis
- Fundamentals of geometric nonlinearity for discrete structural systems
- Material nonlinearity, geometric nonlinearity
- Factors affecting nonlinear behavior of structures
- Geometrical and material effects
- Statically determinate and statically indeterminate flexible bars of uniform and variable thickness
- Structural analysis of Buddhist architectures.

Unit 2 Buckling analysis (6 Hrs.)

- Principles of stability and buckling analysis for discrete structural systems
- Instability phenomena (snap-through, bifurcation, post-buckling phenomena)
- Principles of stability and buckling analysis for discrete structural systems.

Unit 3 Types of Nonlinear analysis (9 Hrs.)

- Nonlinear solution techniques: General time independent structural problem, nonlinearity in stress analysis
- Geometric, material, contact. Secant and tangent stiffness matrices, non-linear stiffness matrix analysis.
- Some non-linear solution methods: Incremental methods; iterative method with initial stiffness and tangent stiffness; Newton-Raphson method; modified Newton-Raphson method.
- Solution strategies for nonlinear system of equations; incremental single-step methods; Euler method, second-order Runge-Kutta methods. Numerical calculations using different methods in a

simple spring assembly.

- Nonlinear solution procedures for tracing equilibrium paths geometrically nonlinear finite elements for one-dimensional structural systems.
- Material nonlinear finite elements for one-dimensional structural systems. Modeling of 2D and 3D frames using 1D nonlinear beam-column elements.

Unit 4 Nonlinear dynamic analysis, vibration theory (9 Hrs.)

- Nonlinear dynamic analysis of discrete structural systems
- Nonlinear dynamic analysis of discrete structural systems
- Vibration theory and analysis of flexible members
- Hysteretic models and analysis of uniform and variable stiffness members under cyclic loading.

Unit 5 Inelastic analysis of flexural members (9 Hrs.)

- Inelastic analysis of uniform and variable thickness members subjected to small deformations; inelastic analysis of flexible bars of uniform and variable stiffness members with and without axial restraints

Unit 6 Elastic and inelastic analysis of plates (6 Hrs.)

- Elastic and inelastic analysis of uniform and variable thickness plates
- Application of this in Buddhist Architectural system.

References:

1. Fertis, D.G. (1999). *Nonlinear Mechanics*, CRC Press
2. Reddy, J.N. (2008). *Nonlinear Finite Element Analysis*, Oxford University Press
3. Sathyamoorthy, M, (2010). *Nonlinear Analysis of Structures*, CRC Press
4. Gang, L. and Kevin Wong, K.F. (2014). *Theory of Non-linear Structural Analysis*, John Wiley & Sons

MBSE 551: Design of Motor Bridges

Year I, Semester II	
Course Title : Design of Motor Bridges	Course Code: ***MBSE* 551**
Nature of the Course : Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- The main objective of this course is to develop a fundamental understanding of designing of a bridge and its components. To visualize the effect of different traffic loads and their relationship. To know about the various design aspects and their considerations for RCC and steel bridges. To know about the various procedures available for construction, maintenance and retrofit.

Unit 1. Introduction to bridge engineering (3 Hrs.)

- Introduction to bridge engineering and components of bridge.
- Historical background of bridges and types.
- Bridge aesthetics and proportioning.
- Design process. Review of applicable design codes.
- Loads on bridges and force distribution.
- Bridge geometry. Introduction and selection of type of Bridges and their axis;
- Layout of bridge axes; Introductory part of using IS code IRC and other codes loading on bridge
- Data required for design of bridge
- Bridges with Buddhist architectural designs.

Unit 2. Bridge type selection and Analysis (3 Hrs.)

- Combination of gravity load and seismic performance in bridge
- Theories of Lateral Load distribution on bridge
- Grillage Analogy
- Seismic Analysis for bridge
- Introductorily part of geo- tech and soil treatment
- Hydrological analysis

Unit 3. Review of RC Bridge Design with Long/short Span (9 Hrs.)

- Design of RC Bridge; continuous girder bridges, balanced cantilever bridges
- Design of Composite Bridges (Steel and Concrete Design of RC Box girder bridges
- Introductory part of Geotech and soil treatment in design of bridges
- Arched Bridge design
- Balanced cantilever bridges
- Analysis and design of Slab Bridge
- Skew Slab Bridge
- T- girder Bridge
- Flyover bridge analysis and design

Unit 4. Design of Steel bridge (9 Hrs.)

- Vehicle, Railway loadings, dynamic effect consideration
- Vehicle, Railway culvert bridge with steel beams
- Plate girder bridges
- Box girder bridges
- Steel Truss bridges
- Vertical and Horizontal stiffeners.

Unit 5. Prestressed and post tension concrete bridges (9 Hrs.)

- Flexural and torsional parameters – Courbon's theory
- Distribution co-efficient by exact analysis
- Design of girder section – maximum and minimum prestressing forces
- Live load and dead load shear forces
- Cable Zone in girder – check for stresses at various sections – check for diagonal tension – Diaphragms – End block – short term and long term deflections post tension concrete bridges design.

Unit 6. Bearing and Substructure design (6 Hrs.)

- Design of Bearings
- Plates in bridge
- Design of abutments, piers and their foundations
- Types of bridge foundations
- Design of foundations; Open well, Sinking well foundation, pile foundation

Unit 7. Repairing and retrofitting of bridge **(6 Hrs.)**

- Earthquake Damages of Bridges
- Structural Deficiencies
- Retrofit Philosophy and steps, Jacketing; steel, concrete and composite jacketing, smart material
- Maintenance of bridges
- Research and development
- Issues: Recent Advances in Retrofitting Techniques

References:

1. Victor, J.D. (1973). *Essentials of Bridge Engineering*, Oxford University Press.
2. Raju, N.K. (2019). *Design of Bridges*, Oxford & IBH Publishing Co.Pvt.Ltd, New Delhi
3. Jagadeesh,T.R. and Jayaram,M.A., (2004). *Design of Bridge Structures*, Prentice Hall of India Pvt. Ltd.
4. Ponnuswamy, S. (2008). *Bridge Engineering*, Tata McGraw Hill
5. Raina, V.K. (1991). *Concrete Bridge Practice*" Tata McGraw Hill Publishing Company, New Delhi
6. Rajagopalan, N., (2006). *Bridge Super Structure* (First Edition), Narosa Publishing House Pvt. Ltd.
7. Beckett, D. (1973). *An Introduction to Structural Design of Concrete Bridges*, Surry University
8. Taylor, F.N., Thomson, S.E. & Smulshi, E. (1999). *Reinforced concrete Bridges*, John Wiley
9. Balcht, B. & Jaegar, L.G. (1985). *Bridge Analysis Simplified*, McGraw Hill

MBSE 553: Application of Finite Element Method (FEM)

Year I, Semester II	
Course Title: Application of Finite Element Method (FEM)	Course Code: ***MBSE* 553**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

- The objective of this course is to make the students able for analysis of various structures in discrete form and negotiate and support with base knowledge for further development.
- Computer Aided Design - programming.

Unit 1. Background on variational calculus (6 Hrs.)

- Galerkin methods
- Collocation methods, least squares Methods.
- Variational methods of approximation- Rayleigh-Ritz method
- Variational theorem; Principle of minimum potential energy,
- Use of polynomial displacement function a rational approach for formulation of element stiffness matrix for truss and beam elements.
- Applications of FEM in Buddhist architecture.

Unit 2. Two dimensional elements in plane stress /plane strain problems (6 Hrs.)

- Two dimensional elements in plane stress /plane strain problems.
- CST, LST & Rectangular Elements
- Modeling considerations; aspect ratio • Use of polynomial displacement functions
- Pascal triangle.
- Requirements for convergence
- Geometric Invariance, Grid refinement

Unit 3. Standard stiffness and load vector (3 Hrs.)

- Standard stiffness and load vector formulation procedure using variational principle.

Unit 4. Shape functions in Cartesian & natural coordinate systems **(6 Hrs.)**

- Shape functions in Cartesian & natural coordinate systems - Shape functions for one Dimensional element such as truss & beam.
- Shape function for two dimensional elements.
- Three dimensional elements such as Tetra hydron, Hexahydron
- Shape functions, stress strain relations

Unit 5. Axisymmetric elements in axisymmetric problems **(3 Hrs.)**

- Axisymmetric elements in axisymmetric problems
- Stress strain relations
- Triangular and Quadrilateral elements.

Unit 6. Concept of isoparametric elements and isoparametric mapping **(6 Hrs.)**

- Concept of isoparametric elements and isoparametric mapping
- Jacobian Matrix
- Formulation Procedure for 2 D quadrilateral isoparametric element in plane elasticity problem
- 3-D isoparametric elements.

Unit 7. Thin Plate bending elements **(6 Hrs.)**

- Various Triangular and Rectangular elements,
- ACM (Adini, Clough, Melosh) and BFS (Bogner, Fox, Schimdt) elements
- Conforming & nonconforming elements
- Concept of four nodded & eight nodded Isoparametric elements
- Mindlin's hypothesis for plate bending element.

Unit 8. Flat & curved shell element **(6 Hrs.)**

- Elements for cylindered shells
- Curved solid element Ahmad's degenerated solid element
- Pawsey's eight nodded shell elements.

Unit 9. Recent developments in numerical modelling for analysis of structures **(3 Hrs.)**

- Recent developments in numerical modelling for analysis of structures
- Use of this in Buddhist Architecture.

Books

1. Bhavikatti, S.S. (2010). *Finite Element Analysis*, New Age International Publishers, Delhi
2. Thompson, E.J. (2009). *Introduction to the Finite Element, Method*: Theory, Programming and Applications, Wiley, India
3. Krishnamoorthy, C.S. (1994). Finite Element Analysis – Theory & Programming – Tata McGraw Hill Publishing Co. Ltd
4. Zienkiewicz, O.C. & Taylor, R.L. (1991). *The Finite Element Method*, 4th Edition, Vol – I & II – McGraw Hill International Edition
5. Robert, D.C., Malkus, D. E. & Plesha, M.E. (2001). *Concepts & Applications of Finite Element Analysis*, Wiley, India.
6. Reddy, J.N. (2007). *An Introduction to the finite element method*, Tata McGraw Hill Publishing Co. Ltd
7. Rao, S.S. (2001). *The Finite Element Method in Engineering*, 4th Edition, Elsevier Publication
8. Buchanan, G. R. (2005). *Finite Element Analysis Schaum's outlines*, Tata McGraw Hill Publishing Co. Ltd
9. Segerlind, L.J. (1984). *Applied Finite Element Analysis*, John Wiley & Sons.
10. Shames, I. & Dym, C. (1995). *Energy & Finite Element Methods in Structural Mechanics*, New Age International Publishers,

Year II Semester III
Core Subjects

MBSE 559 Project Work

Year: II/I; Semester: III	
Course Title: Project Work on Structural Engineering (SE)	Course Code: MBSE 559
Nature of the Course: Theory + Tutorial	Per week Hours: (3+1)
Credit: 4	Total Hours: 60

Course Objective:

- The course is to build the practical knowledge and skills of the students on an independent study of specimen projects and presentation of the research in an academic approach.

The Project work

The project will focus on the context of structural engineering, with an emphasis on cultural heritage sites. Examples of cultural heritage sites could include iconic buildings, historical structures, or monuments. The project aims to help students to explore current trends in structural engineering, such as sustainable design, digital modeling, and advanced materials.

Students will be organized into groups or assigned individual projects by the college. Each group or individual will carry out the assigned project work. The project work should align with the research area and objectives defined in the project guidelines.

Students will follow the project work guidelines provided by the college. They will prepare a high-standard report that meets the college's requirements. The report should cover the research methodology, literature review, analysis techniques, design considerations, and recommendations for disaster planning and management specific to cultural heritage structures. The report will be evaluated by the supervisor(s) based on predefined criteria such as research depth, analysis, clarity of presentation, adherence to guidelines, and overall quality.

The evaluation of this course will be only internal.

Reference: Latest research papers

Electives I

MBSE 603: Design of Hydraulic Retaining Structures

Year II, Semester III	
Course Title: Design of Hydraulic Retaining Structures	Course Code: ***MBSE* 603**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

Students will:

- To gain of knowledge of Hydropower plants and their components.
- To design process overview of hydraulic structures of the hydropower plants
- To perform structural analysis and design of the major components of RoR type hydropower plants
- To design different various types of hydraulic retaining structures.

- Types of loads and their application in different components of the hydropower plants. Structural analysis and design of the various types of dams. Structural analysis, design and dimensioning of the major components of RoR type hydropower plants structural analysis and design of hydro-mechanical parts of the hydropower plants such as gates and trash racks

Unit 1. Introduction to the Hydropower Plants (3 Hrs.)

- Types of Hydropower schemes
- Storage types of hydropower plants and its components
- Run of River or Peaking type of Run of River Hydropower plants and its major components;
- Major hydropower plants in Nepal and their special features

Unit 2. Design Process of Hydropower Components (9 Hrs.)

- Introduction
- Design process overview
- Collecting information
- Prepare design criteria
- Determine loading; Preliminary layout and sizing of structure
- Preliminary stability analysis

- System analysis (stability, foundation pressure and frictional resistance; concrete stress);
- Component Analysis; Detailed Design; Drawing and Specification;
- Quality Control and Assurance

Unit 3. Design of Concrete gravity dams **(9 Hrs.)**

- Types of Concrete Dams; Gravity Dams
- Design Loads: (Dead loads, Geotechnical loads, Hydrostatic and hydrodynamic loads, Seismic, Ice, Wind, Snow and other loads; Load Combinations
- System analysis (stability, foundation pressure and frictional resistance; concrete stress)
- Arch/Buttress Dams; Design Loads: (Dead loads, Geotechnical loads, Hydrostatic and hydrodynamic loads, Seismic, Ice, Wind, Snow and other loads
- Load Combinations; System analysis (stability, foundation pressure and frictional resistance; concrete stress)

Unit 4. Design of Embankment Dams **(6 Hrs)**

- Introduction and types of embankments dams
- Principles of embankment dam design
- Foundation Design
- Slope stability analysis
- Design of filters and cores
- Resettlement and Deformation analysis

Unit 5. Design of RoR and PRoR hydropower plants and its components **(12 Hrs)**

- Introduction to the RoR and PRoR hydropower plants
- Design of components
- Design of Weirs and Intakes
- Hydraulic and Structural Design
- Design of Gravel trap and Settling Basins
- Design of head race tunnel/channel
- Design of fore bay/ surge tank
- Design of Steel Penstock Pipe
- Design of Anchor Blocks, Thrust Blocks and Support piers
- Power house design
- Tailrace tunnel/channel design

Unit 6. Design of machine foundation **(6 Hrs.)**

- Introduction
- Hydraulic gates; Introduction; types;
- Structural consideration
- Detail design aspects
- Design of machine foundation for Buddhist structures.

References:

1. Novak, P., Moffat, A.I.B. and Nalluri, C. (2007). *Hydraulic Structures* : Fourth Edition: School of Civil Engineering and Geosciences, University of Newcastle upon Tyne, UK and R. Narayanan Formerly Department of Civil and Structural Engineering, UMIST, University of Manchester, UK.
2. US Department of the Interior, Bureau of Reclamation. (1974). *Design of Small Dams,* A Water Resources Technical Publication, Oxford and IBHP Publication Co. Pvt. Ltd.
3. United States Department of the Interior Bureau of Reclamation. (1974), *Engineering Monograph No. 19 Design Criteria for Concrete Arch and Gravity dams,* Office of Design and Construction Engineering and Research Center Denver, Colorado 80225
4. The committee on the hydropower intake and energy division of the American Society of the Civil engineers (ASCE). (2014). *Guidelines for design of intakes for hydroelectric plants*, Published by ASCE, 345 East 47th Street New York, 10017-2398 New York

MBSE 604: Pre-stressed concrete

Year II, Semester III	
Course Title: Pre-stressed concrete	Course Code: ***MBSE* 604**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course objective

- To get exposed to various systems of pre-stressing.
- To understand the design of flexural members for shear, bond and torsion and end blocks.
- To acquire knowledge on continuous beams and their design.
- To be familiar with the design of the tension and compression members and the process of pre-stressing.
- To attain knowledge ferrocement.

Unit 1: Introduction to pre-stressed concrete (9 Hrs.)

- History and Development of Precast concrete construction
- Advantages and disadvantages of precast concrete construction
- Different types of units involved in general building construction, including residential, factory and industrial framed structure;
- General principles of design
- Mechanical handling of large projects like stadium, bridges etc.
- Materials viz. Concrete, Self-Compacting Concrete, Grout, Reinforcement and structural welded wire cages.
- Requirements of industrialized buildings, standardization of precast elements and unification of building design.
- Influence of manufacture, transport and erection technologies on design solution (Modular and Tilt-Up); expansion and contraction joints.

Unit 2: Prefabricated Components and Its Behavior (9 Hrs.)

- Design of Precast Concrete Components and Behavior of structural components
- Large panel Constructions
- Construction of roof and floor slabs
- Wall panels, Beams, Columns, Shear walls.
- Design for Flexure: Strength Design (Depth of Stress block, Flanged Elements, strength reduction factor, limitations on reinforcement, Critical sections)

- Service load design. Design for Shear: Horizontal and vertical shear resistance.

Unit 3: Joints and Connections **(6 Hrs.)**

- Joints and connections in precast construction
- classification and their requirements
- Design of Concrete bracket and corbels
- Cantilever beam-design method
- Strut-and-tie method
- Introduction to Hanger Connections
- Design of bearing pads, column bases and moment connections.
- Typical connection designs for lateral load resisting systems.

Unit 4: Design of Ferrocrete Structures **(6 Hrs.)**

- Design, analysis and optimization
- Special design considerations
- Typical features of Ferrocrete affecting design
- Design criteria
- Rational method of design Ferrocrete structure.
- Strength through shape
- Shape and form of a structure
- Various structural forms and their behavior
- Comparative study of various forms

Unit 5. Deflections calculation prestressed concrete structure **(9 hrs.)**

- Introduction
- Factors influencing deflections
- Short term and long-term deflections of uncracked and cracked members for prestressed concrete structure.

Unit 6. Circular prestressing **(6 hrs.)**

Introduction

- Circumferential prestressing
- Design of Prestressed concrete tanks
- Vertical prestressing in tanks
- Dome prestressing and Concept of Buddhist monasteries domes

Reference Books

1. Divekar, Dr. D.B. (2018). *Ferrocement Construction Manual*, Shivaji Nagar, Model Colony, Pune
2. Mezisakar, T. (1990). *Building materials and components*, CBRI, India
3. Gerostiza, C.Z., Hendrikson, C. and Rehat, D.R., (1994). *Knowledge based process planning for construction and manufacturing*, Academic Press Inc.
4. Martin, L.D., & Perry, C. J., (2004). *PCI Design Handbook*, Precast and Prestressed Concrete (6th Edition), ISBN – 0-937040-71-1.
5. Koncz, T. (1971). *Manual of precast concrete construction*, Vols. I, II and III, Bauverlag, GMBH
6. Koncz, T. (1978). *Structural design manual*, Precast concrete connection details, Society for the studies in the use of precast concrete, Netherland Betor Verlag
7. ACI committee, (1997). *State-of-the-art report and guide for Design, Construction and Repairs of Ferrocement*, Report. No ACI549R- 88 and ACI 549.1R.88. Published by American Concrete Institute, Detroit, USA
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9. Naaman, A.E. (2000). *Ferrocement and laminated cementitious composites*, Technopress, Ann Arbor, Michigan, U S A.
10. Namaan, A.E. (1979). *Ferrocement- Materials and Applications*, Publication SP 61, A C I Detroit. U S A
11. Kulkarni, P.D. & Ghosh, Dr. R.K. (2017). *Concrete Technology*, New Age International Publishers
12. ACI committee 549. (2018). *Ferrocement code*, ACI 549.1R

Electives II

MBSE 605: Rock Mechanics and Tunneling

Year II, Semester III	
Course Title: Rock Mechanics and Tunneling	Course Code: ***MBSE* 605**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

A fundamental knowledge of the nature of rock and behavior of structures under the ground motion are necessary in order to analyze and design structures rationally against seismic excitations. A fundamental knowledge of the nature of geotechnical features and behavior of structures under the ground motion are necessary in order to analyze and design tunnel rationally against seismic excitations. The course gives a basic understanding of the analysis and design of tunnel subjected to earthquakes and design of structures to resist in various types of rock and soil strata below ground level.

Unit 1. Introduction to Rock Mechanics and tunneling (3 hrs.)

- Scope of rock mechanics;
- Concept of intact rock and rock mass and associated engineering properties;
- Rock mass discontinuities and their characterization:
- Geological data collection and interpretation for Buddhist monasteries and structures

Unit 2. Analysis of rocks (6 hrs.)

- Rock testing;
- Rock mass classification;
- Rock stresses and methods of stress analysis;
- Shear strength of rock and rock masses;
- Factors affecting the shear strength of rock and rock mass,
- Strength of rock and rock mass,
- Factors affecting the multi axial strength of rock and rock mass.

Unit 3. Groundwater in rock (9 hrs.)

- Effect of groundwater in assessing the engineering behavior of rock and rock mass,
- Rock dynamics; dynamic properties of rock; rock dynamics related to blasting and earthquakes,
- Seismic risks associated with earthquakes.
- Rock foundations: analytical and empirical design of rock foundations taking into consideration in situ rock conditions

Unit 4. Rock slope engineering(9 hrs.)

- Types of rock slope failures,
- Analysis of various modes of rock slope failures.
- Method of stabilizations of rock slopes.
- Design of cuts and fills in rock and other rock slope stabilization measures.

Unit 5. Introduction of tunneling (3 hrs.)

- Site investigations
- Survey,
- Geotechnical considerations of tunneling with seismic excitation

Unit 6. Analysis Design of Tunnels (6 hrs.)

- Rock and soil stresses
- Methods of stress analysis in tunneling
- Principal stresses
- Stress concentration in tunneling,
- Design of tunneling.

Unit 7 .Tunneling techniques, Tunnel support design (9 hrs.)

- Micro tunneling
- Support design of tunneling
- Design of entrance in tunneling

References:

1. Godman, P.E. (1989). *Introduction to Rock Mechanics*, John Wiley, New York
2. Jager, G. (1972). *Rock Mechanics and Engineering*, Cambridge University Press
3. Stillborg, B. (1986). *Professional user handbook for rock bolting*, Tran Tech Publications
4. Hock, E. and Brown, E.T. (1980). *Underground excavation in rock*, Institute of Mining and metallurgy
5. Hock, E. and Bray, J. (1981). *Rock slop Engineering*, Institute of Mining and Metallurgy
6. Bickel, J.O., Kuesel, T.R.(2018).*Tunnel Engineering Handbook* ,CBS Publishers and Distributers
7. Bieniawski, Z.T., Balkema, A.A. (1984). *Rock Mechanics Design in Mining & Tunneling*, CBS Publishers and Distributors Pvt Ltd.
8. Srinivasan, R. (2015). *Harbour & Dock & Tunnel*, Charotar Publishing House Pvt. Ltd.
9. Saxena, S.C. (2015). *Tunnel Engineering*, Dhanpat Rai Publications

MBSE 606: Buddhist Infrastructure Engineering

Year II, Semester III	
Course Title: Buddhist Infrastructure Engineering	Course Code: ***MBSE* 606**
Nature of the Course: Theory	Per week Hours: 3
Credit: 4	Total Hours: 45

Course Objectives:

To provide fundamental knowledge of Buddhist Infrastructure Engineering and Buddhist architecture as well as historical background of Buddhist infrastructure development along with structural classification of Buddhist Infrastructure Engineering (BIE) (structural Engineering) (SE). To make capable for students understand the basic philosophy and principal of Buddhism. To study the current scenario of Buddhism in Nepal. Understand how BIE(SE) education can be related and use to flourish the Buddhism. To understand the construction technology used in Buddhist sites and shrines and it is changing nature. To conduct Ethnographical research on Buddhist structure as well as field study in Buddhist historical places (Lumbini and others) for practical understanding.

Unit 1. Introduction to Buddhist Infrastructure Engineering (6 hrs.)

- Importance of Buddhism infrastructure
- Historical background of Buddhism infrastructure development
- Structures classification in Buddhism
- Development procedure Buddhism infrastructures
- Maintenance of Buddhism infrastructures

Unit 2. Buddhist Philosophy (6 hrs.)

- Religion and philosophy
- General philosophical value of Buddhism Triratna – Trisarana ; Punayasambhara and Janasambhara ; Pancha- sila
- Buddhist meditation Samatta meditation and Vipasana meditation
- Concept of Buddhistava in Buddhism
- Motivation for Ethical conduct in social Buddhism
- Concept of Karma ; Dana ;(Liberality) Sila (Moral and Ksanti (Paitent) as key values of Buddhism
- Implication of Buddhist perspective while designing structures

Unit 3. Major Structures of Buddhist architect (6 hrs.)

- Stupa
- Chaitya
- Monastery (Bihar, Gumba)
- Road circumanahalation (Buddhist Circuit)
- Paved and pedestrian path
- Water bodies
- Gardens and forest conservation
- ICT,AI,IOT

Unit 4. Achievements of Buddhist infrastructure structure (4 hrs.)

- Importance Establishment and development of Lumbini University
- Importance establishment and development of Lumbini Development Trust
- Other monuments

Unit 5. Evolution of Buddhist structures (6 hrs.)

- Evolution of Buddhist structure from cave to modern monasteries
- Major structure of Buddhist architecture – with reference to Ajanta cave – Lumbini monasteries
- Evolution in building materials from Clay heap to cave, unborn break to modern construction materials.

Unit 6. Maintenance and preservation of Buddhist sites and shrines (4 hrs.)

- Material and technology for longevity of the structures
- Preservation of ancient Buddhist sites and shrines
- Regular maintenance and sustainability of Buddhist structures

Unit 7. Ethnographical research on Buddhist infrastructure (4 hrs.)

- Ethnographic research
- Research in Buddhist infrastructures
- Major changes in Buddhist infrastructures

Unit 8. Challenges behind religious and non-religious infrastructures (6 hrs.)

- Challenges facing religious infrastructures
- Challenges facing religion social structures
- Differences of religious and social structures
- Influence of modern technology and materials in Buddhist infrastructures

Unit 9. Public participation in Buddhist infrastructure development (6 hrs.)

- Public participation in infrastructure development
- Development practice of religious infrastructures
- Maintenance of Buddhist infrastructures

Unit 10. UNESCO World Heritage site (6 hrs.)

- Short introduction to Buddhist UNESCO heritage sites
- Bauddha stupa area
- Swyambhu stupa area
- Lumbini Buddhist historical sites

Unit 11. Field study in Buddhist historical places (9 hrs.)

- Field study in different Buddhist circuit in Nepal and also develop field visit report and presentation in groups.
- Nepal – Lumbini Circuit- Buddhist Circuit Tour is a pilgrimage; which tours around the historic Buddhist sites of Nepal; which includes Boudhanath, Swyambhunath, Kapan Gompa, Pokhara city, Lumbini, and Chitwan(Narayanghat). The tour covers most of the UNESCO World Heritage sites of Nepal; that holds great importance for Buddhist devotees.

References:

1. Engineering Buddhist infrastructure and soft home in Asia and beyond (2022), *Center for contemporary Buddhist studies, University of Copenhagon, Denmark*
2. Buddha and discourse of monasteries (2009), *David L. Mc Mahan, Oxford University*
3. Dayal Hari (1999), *The buddhisatava doctrine on Buddhist Sanskrit literature*
4. HH dalai lama (1999), *Awakning mind buddhittopada, Taipei, The corporate body of Buddha education foundation*
5. Murti TVS (1980), *The central philosophy of Buddhism, London Unwin Paperback*
6. Piyadsi (1964), *The buddhas ancient path London Rider and Co.*

7. Santina Petter De La (1997), *The tree of inlighment, Taiwan Cico Dharma study foundation*
8. Upadhayaya Valadeva (1978), *Buddha Dharma Mimansa Varanasi, Chaukhamba Vidhyabhawan, India*

Thesis Work

MBSE 650: Research in Structural Engineering (Thesis)

Year II, Semester IV	
Course Title: Research in Structural Engineering (Thesis) Research shall be arranged related to the Buddhist sites and Buddhist structures as far as possible.	Course Code: ***MBSE* 650**
Nature of the Course: Research Work	
Credit: 16	

A thesis guideline consisting of the followings will be provided to the students.

- Framework of research plan
- Manuscript's standards
- Proposals
- Requirements of publications
- Research works
- Presentations
- Acceptance

ANNEX-I: ACKNOWLEDGEMENT

We would like to acknowledge all the experts mentioned in the table presented here for their contribution during revision of this course.

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